US 20140075053A1

(19) United States

(12) Patent Application Publication

(10) Pub. No.: US 2014/0075053 A1

(43) Pub. Date: Mar. 13, 2014

Kolathur et al.

(54) **RUN TIME GENERATION AND FUNCTIONALITY VALIDATION OF DEVICE DRIVERS**

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(21) Appl. No.: **14/026,270**

(22) Filed: **Sep. 13, 2013**

(30) **Foreign Application Priority Data**

Sep. 13, 2012 (IN) 3793/CHE/2012

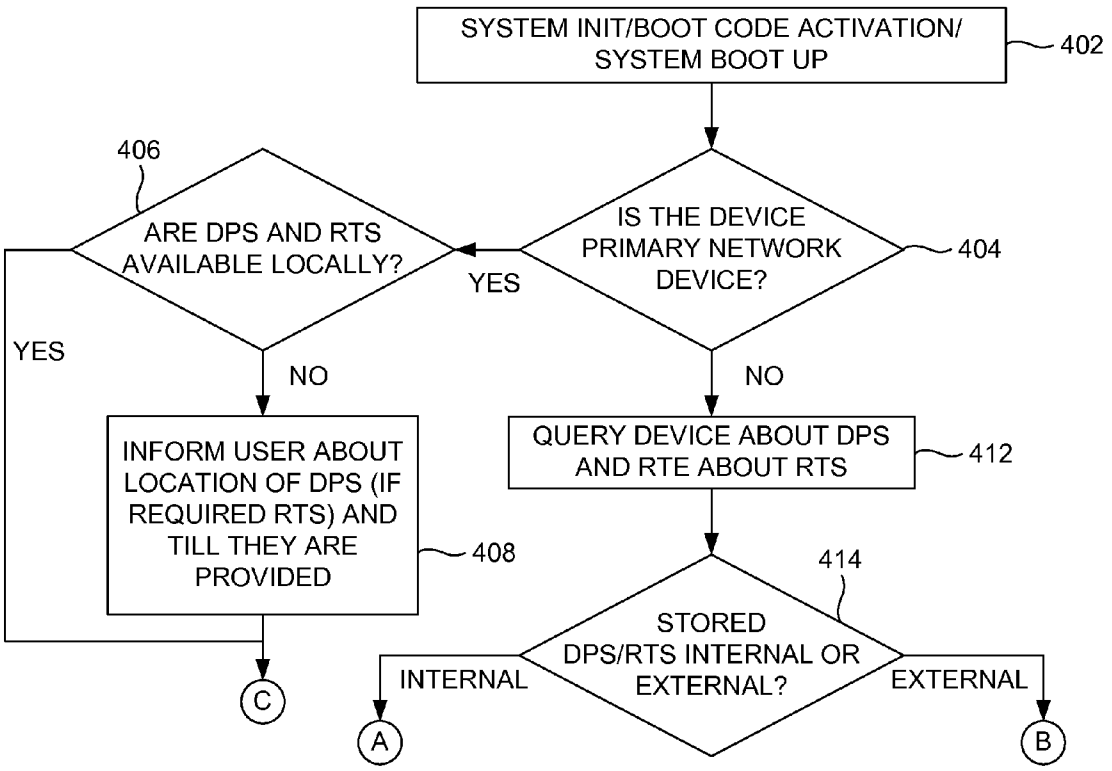
Publication Classification

(51) **Int. Cl.**
G06F 9/44 (2006.01)

(52) **U.S. Cl.**
CPC ***G06F 9/4411*** (2013.01)
USPC **710/10**

(57) **ABSTRACT**

A method of generating and validating a device driver for a hardware device is provided. The method include (i) dynamically querying the hardware device for a device programming specification, (ii) dynamically querying a run time environment for a run time specification, (iii) obtaining the device programming specification that is specific to the hardware device, (iv) obtaining the run time specification that is specific to the hardware device and the run time environment, (v) dynamically synthesizing a device driver, by a device driver generation tool to obtain a synthesized device driver, (vi) automatically testing, by the device driver generation tool, the synthesized device driver based on a device class of the hardware device, and (vii) automatically evaluating, by the device driver generation tool, a performance of the synthesized driver with respect to standard performance parameters for the device class of the hardware device for validating the synthesized device driver.



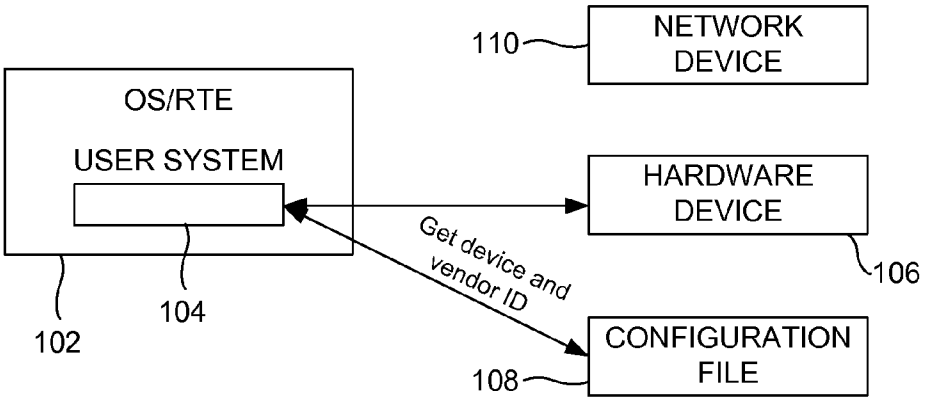


FIG. 1A

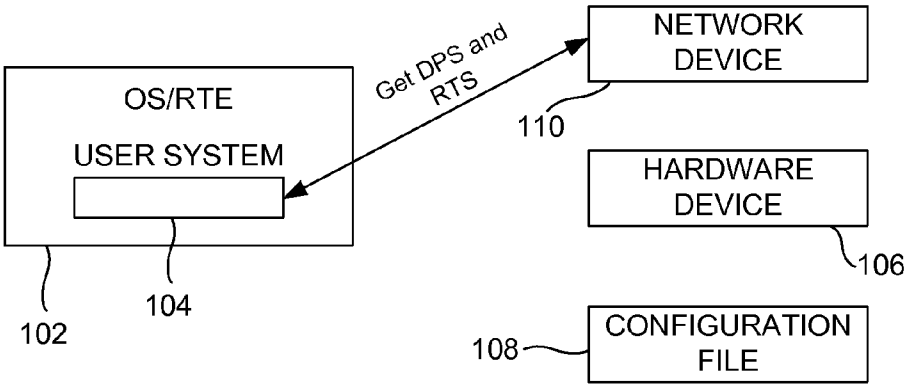


FIG. 1B

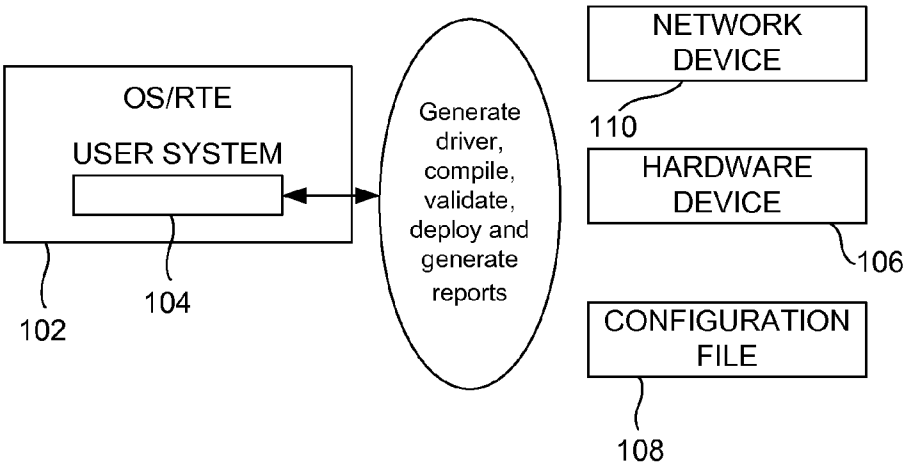


FIG. 1C

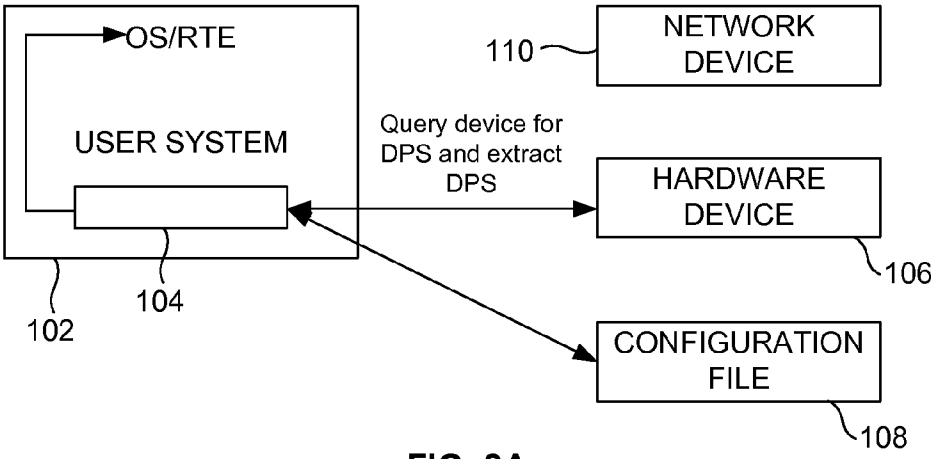


FIG. 2A

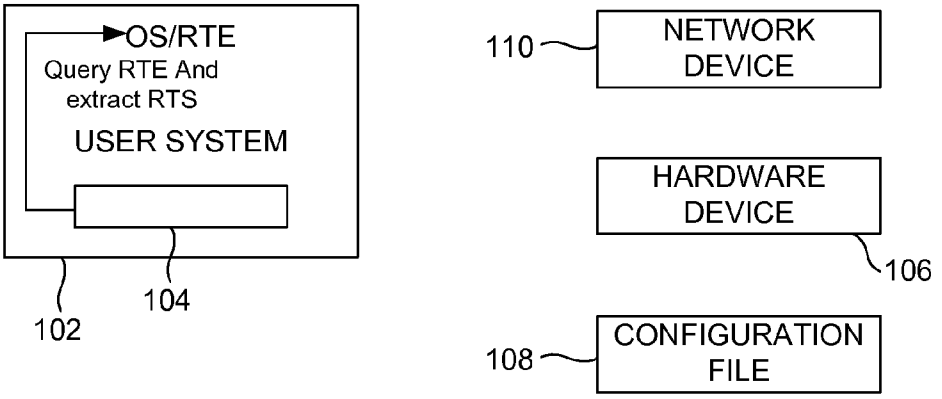


FIG. 2B

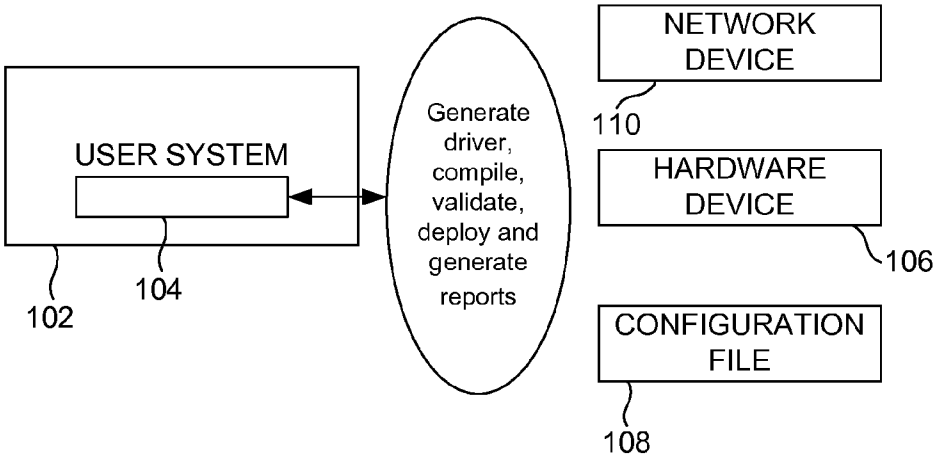


FIG. 2C

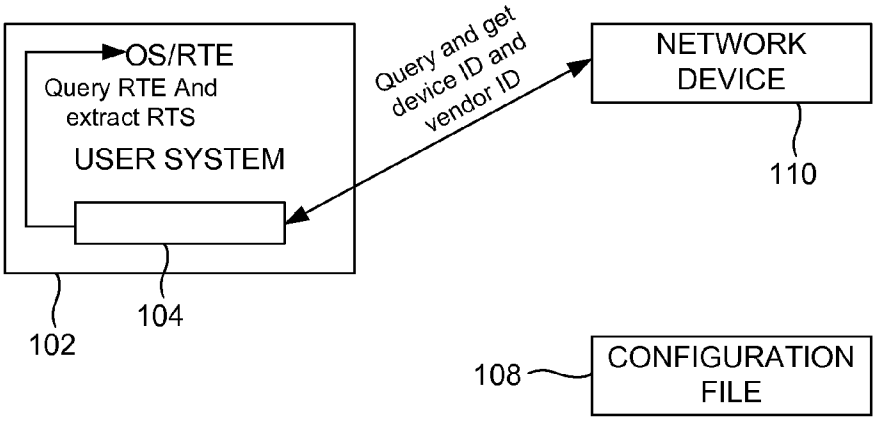


FIG. 3A

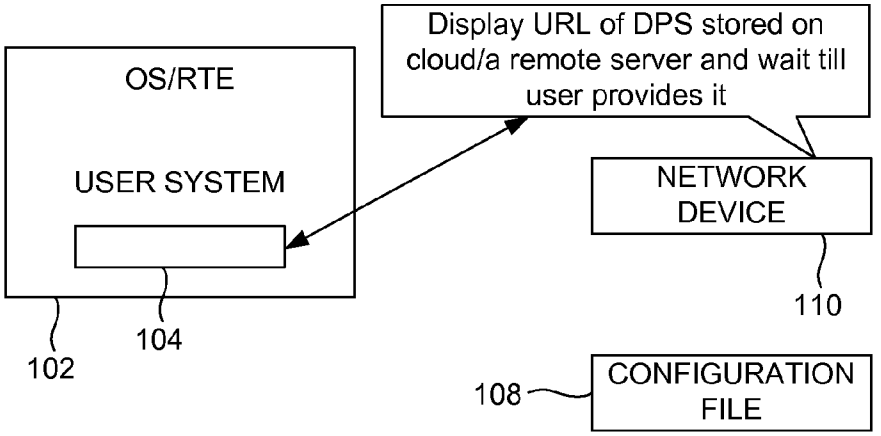


FIG. 3B

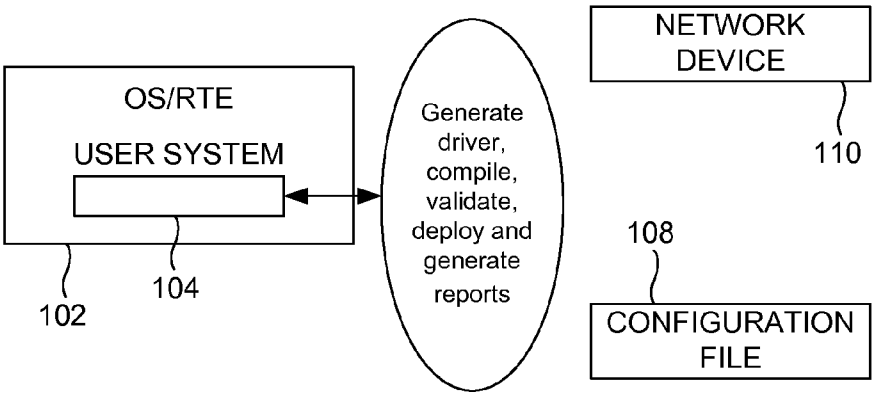


FIG. 3C

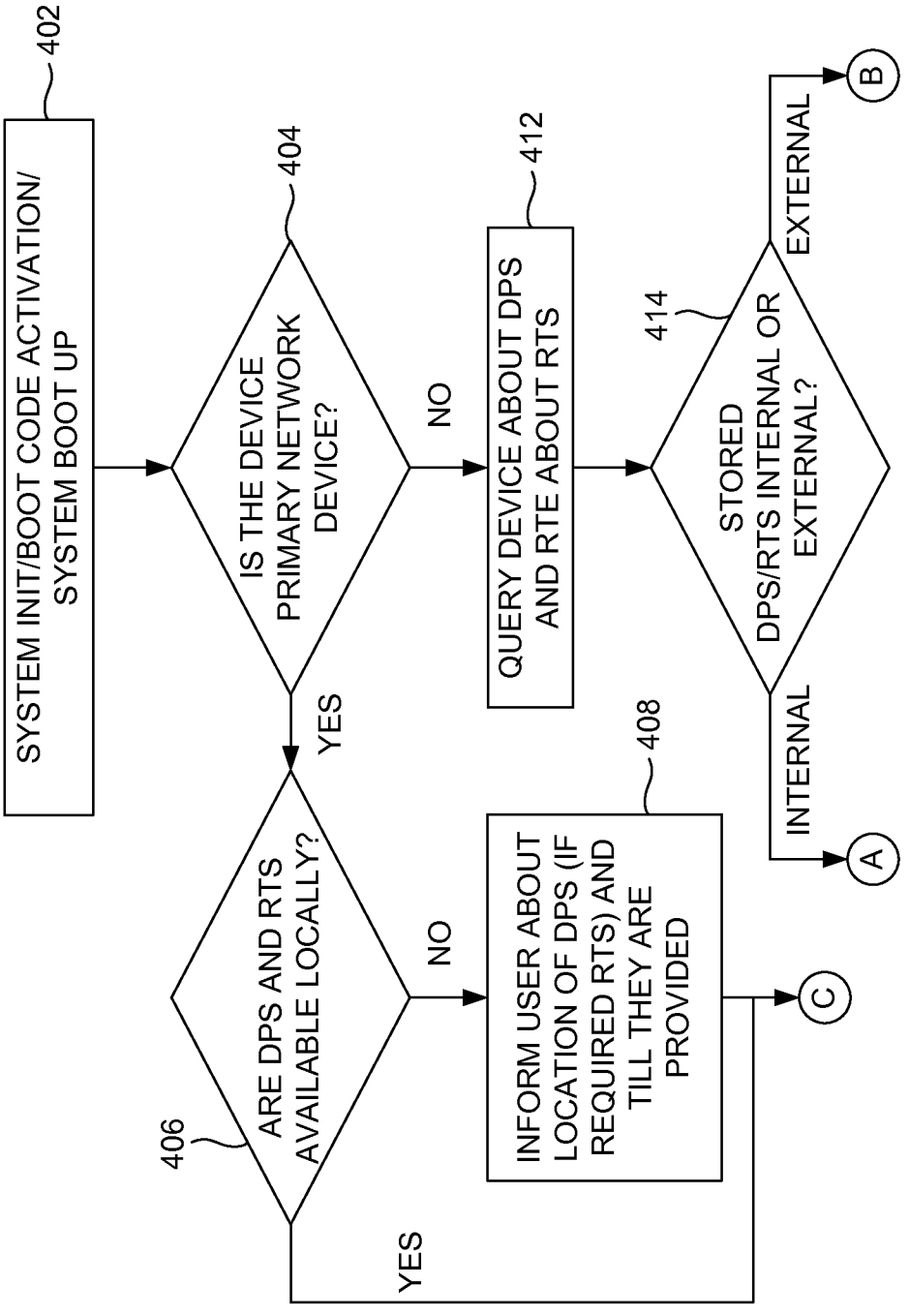

402
SYSTEM INIT/BOOT CODE ACTIVATION/ SYSTEM BOOT UP
404
IS THE DEVICE PRIMARY NETWORK DEVICE?
NO
412
QUERY DEVICE ABOUT DPS AND RTE ABOUT RTS
414
STORED DPS/RTS INTERNAL OR EXTERNAL?
EXTERNAL
B
INTERNAL
A
YES
406
ARE DPS AND RTS AVAILABLE LOCALLY?
NO
408
INFORM USER ABOUT LOCATION OF DPS (IF REQUIRED RTS) AND TILL THEY ARE PROVIDED
C
YES

FIG. 4A

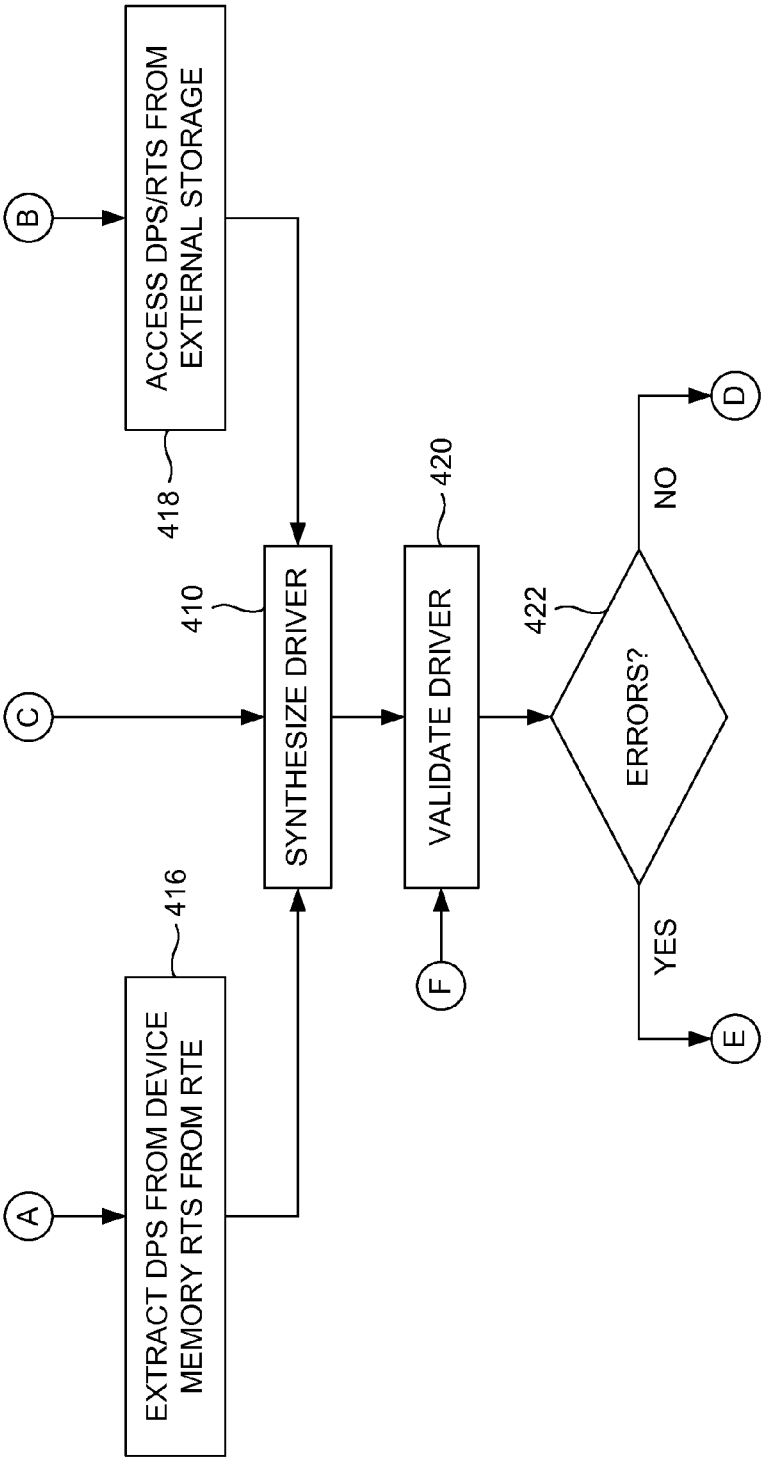

A
B
C
F
EXTRACT DPS FROM DEVICE MEMORY RTS FROM RTE
416
ACCESS DPS/RTS FROM EXTERNAL STORAGE
418
SYNTHESIZE DRIVER
410
VALIDATE DRIVER
420
ERRORS?
422
NO
YES
D
E

FIG. 4B

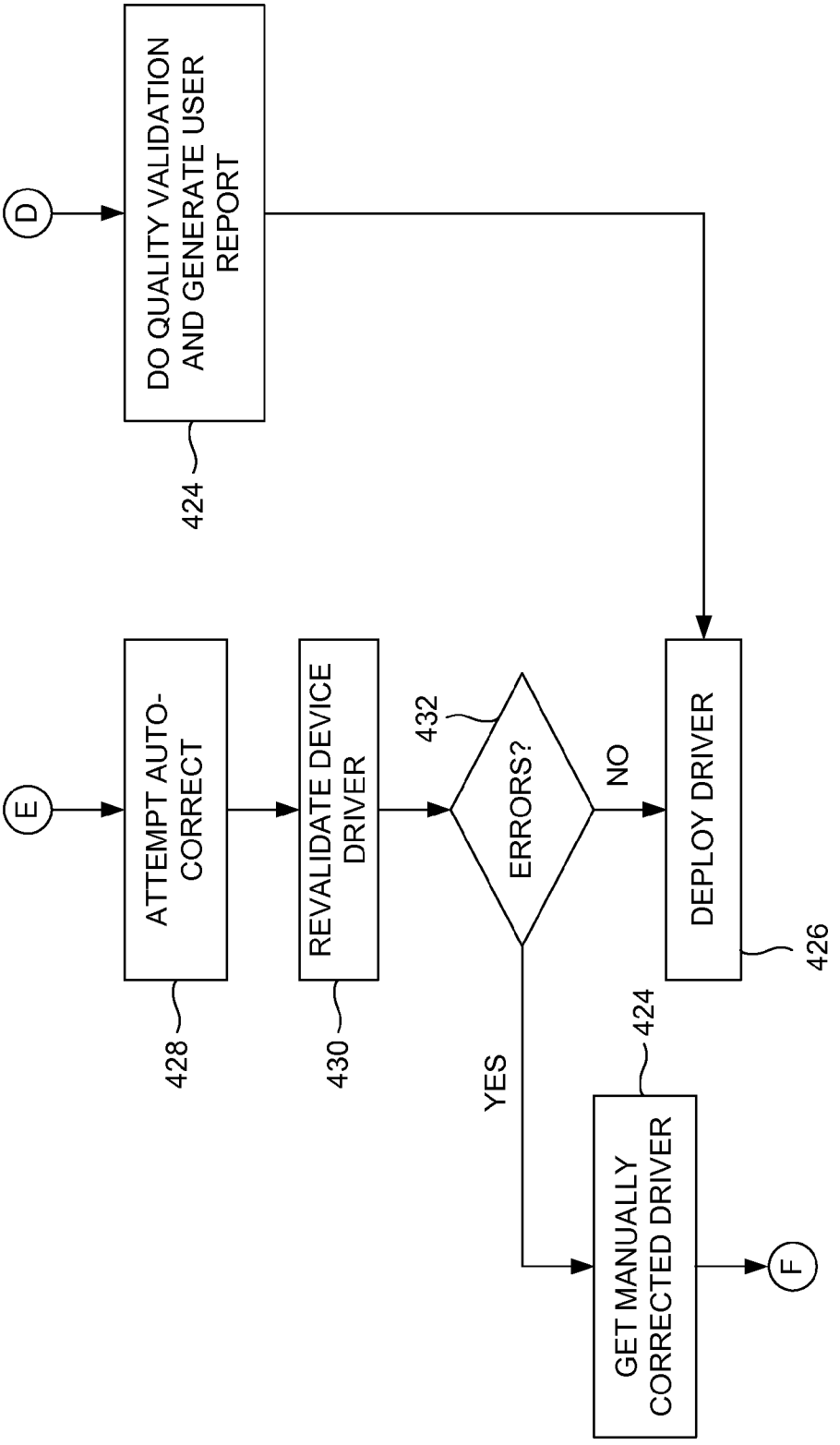

D
DO QUALITY VALIDATION AND GENERATE USER REPORT
424
E
ATTEMPT AUTO-CORRECT
428
REVALIDATE DEVICE DRIVER
430
432
ERRORS?
NO
DEPLOY DRIVER
426
YES
424
GET MANUALLY CORRECTED DRIVER
F

FIG. 4C

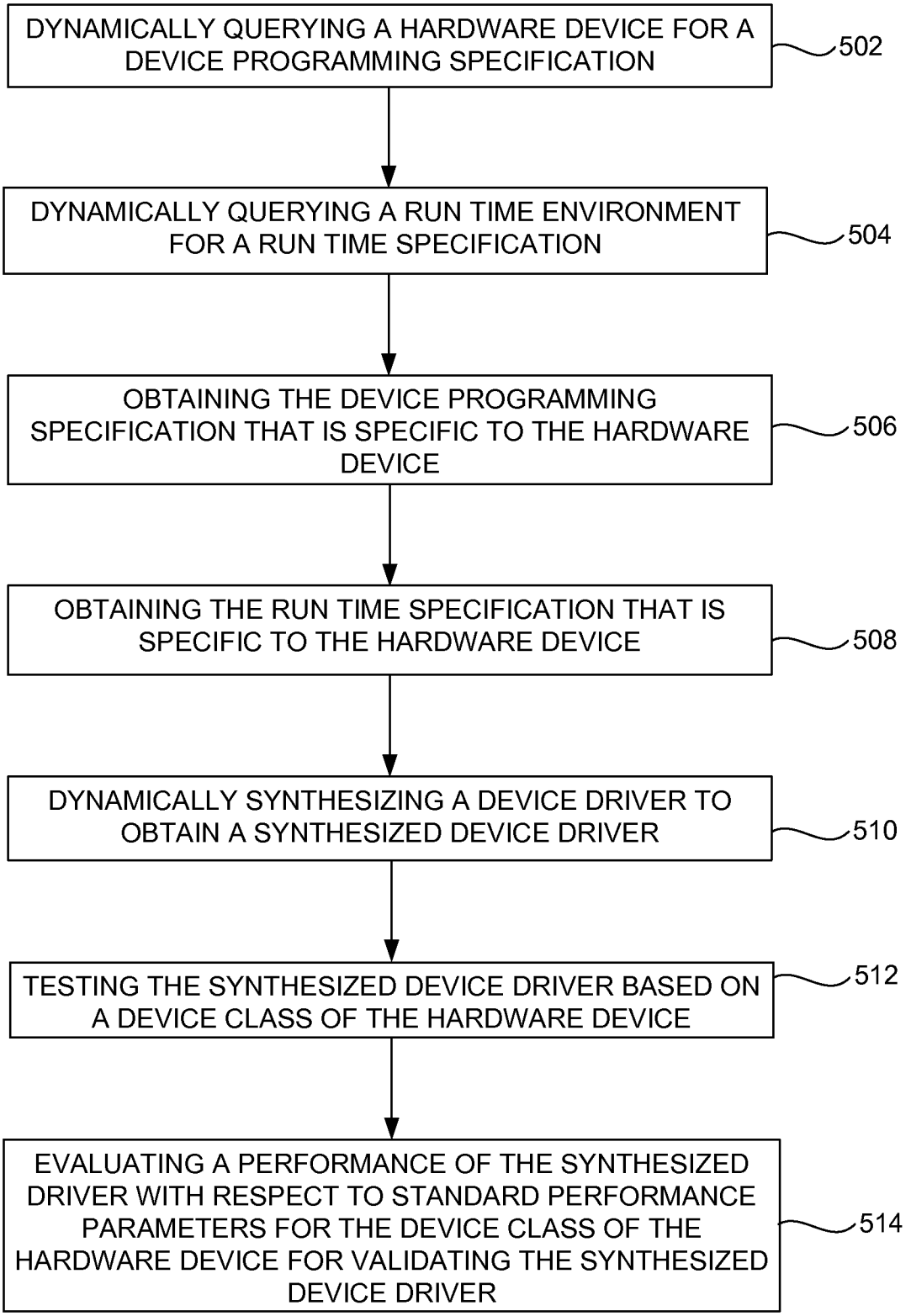

DYNAMICALLY QUERYING A HARDWARE DEVICE FOR A DEVICE PROGRAMMING SPECIFICATION
502
DYNAMICALLY QUERYING A RUN TIME ENVIRONMENT FOR A RUN TIME SPECIFICATION
504
OBTAINING THE DEVICE PROGRAMMING SPECIFICATION THAT IS SPECIFIC TO THE HARDWARE DEVICE
506
OBTAINING THE RUN TIME SPECIFICATION THAT IS SPECIFIC TO THE HARDWARE DEVICE
508
DYNAMICALLY SYNTHESIZING A DEVICE DRIVER TO OBTAIN A SYNTHESIZED DEVICE DRIVER
510
TESTING THE SYNTHESIZED DEVICE DRIVER BASED ON A DEVICE CLASS OF THE HARDWARE DEVICE
512
EVALUATING A PERFORMANCE OF THE SYNTHESIZED DRIVER WITH RESPECT TO STANDARD PERFORMANCE PARAMETERS FOR THE DEVICE CLASS OF THE HARDWARE DEVICE FOR VALIDATING THE SYNTHESIZED DEVICE DRIVER
514

FIG. 5

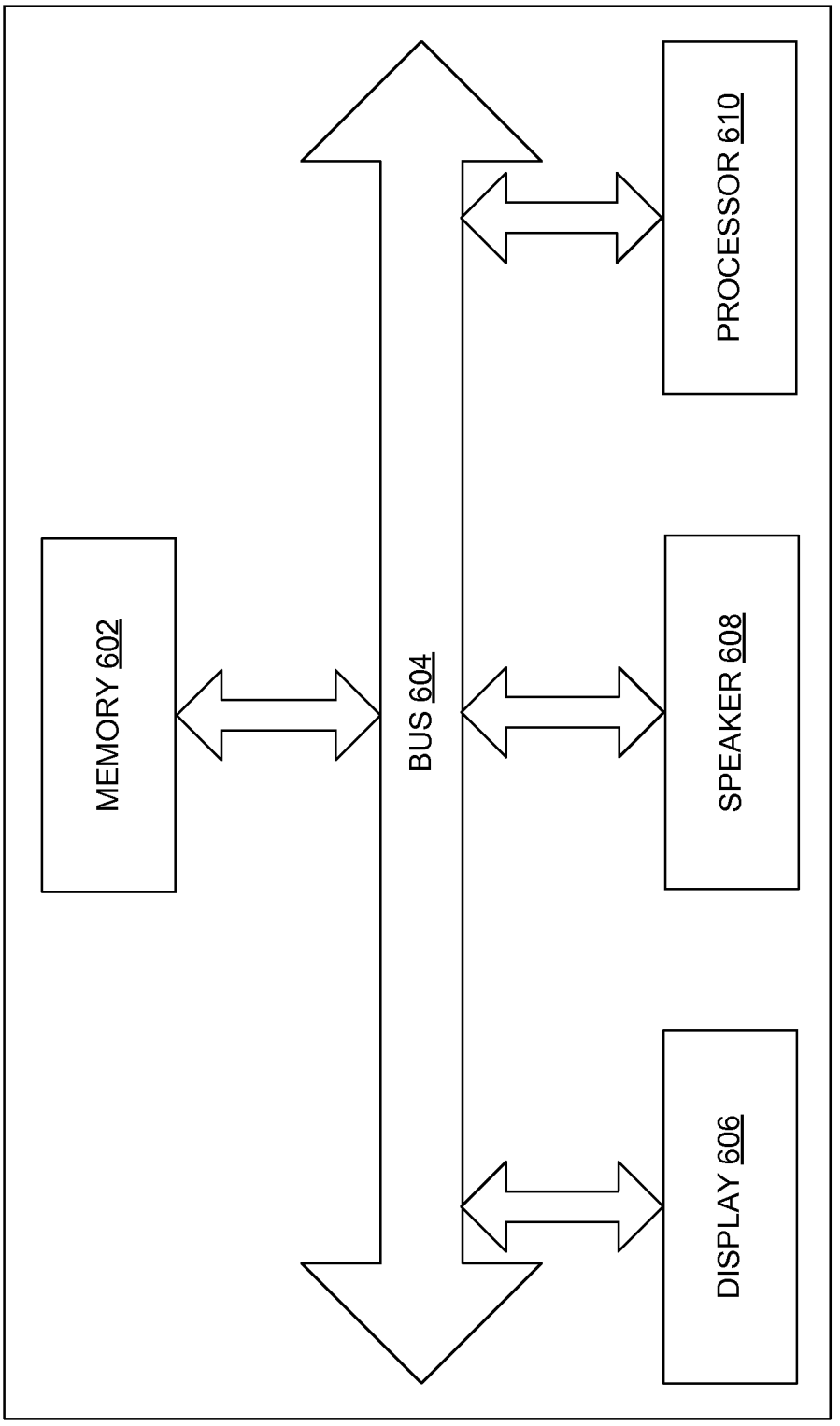


FIG. 6

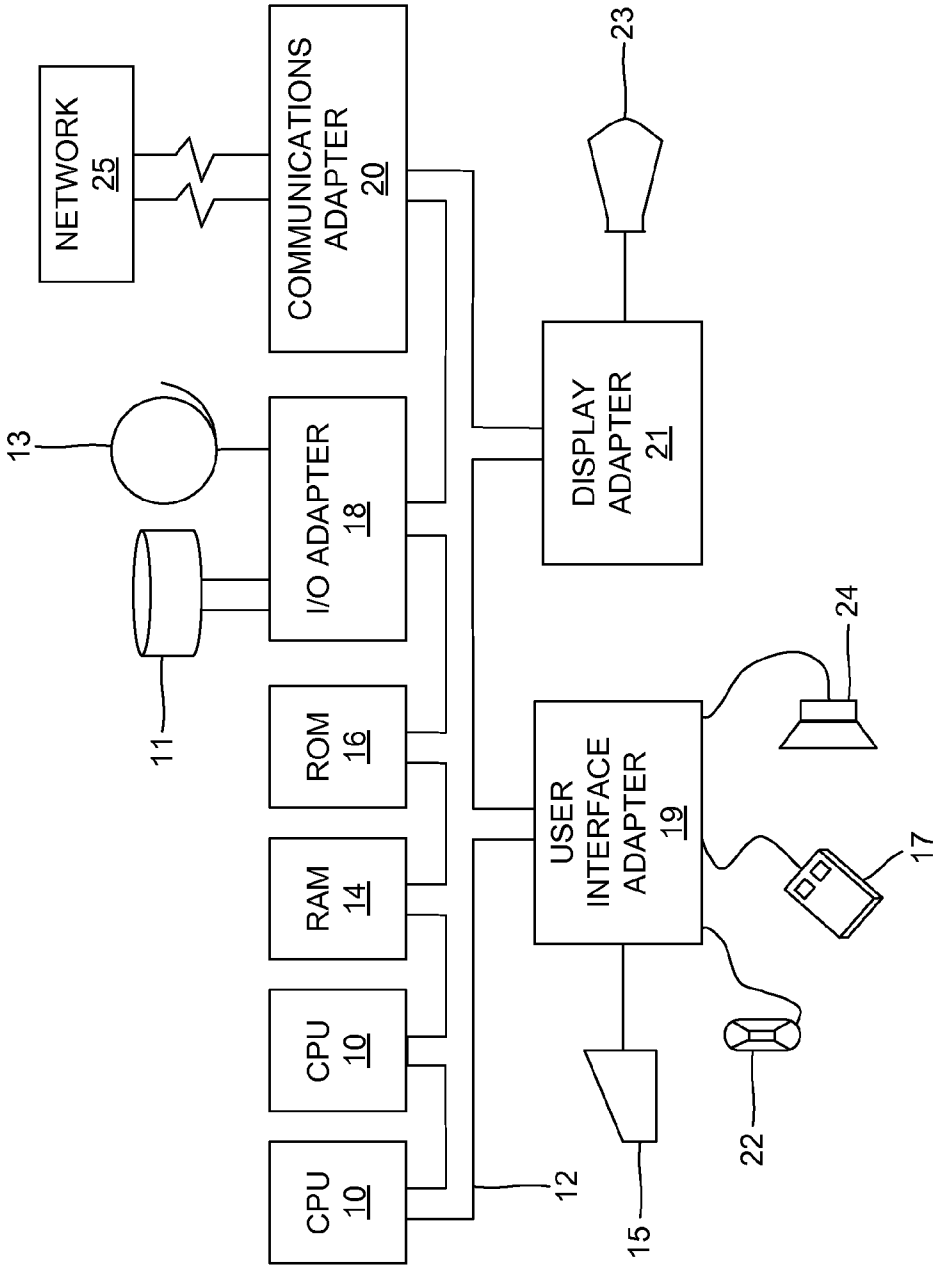

NETWORK
25
COMMUNICATIONS
ADAPTER
20
23
13
I/O ADAPTER
18
DISPLAY
ADAPTER
21
11
ROM
16
24
USER
INTERFACE
ADAPTER
19
RAM
14
17
CPU
10
CPU
10
12
15
22

FIG. 7

RUN TIME GENERATION AND FUNCTIONALITY VALIDATION OF DEVICE DRIVERS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to Indian patent application no. 3793/CHE/2012 filed on Sep. 13, 2013, the complete disclosure of which, in its entirely, is herein incorporated by reference.

BACKGROUND

[0002] 1. Technical Field

[0003] The embodiments herein generally relate to device driver generation for a hardware device, and, more particularly, to a run time generation and functionality validation of device drivers using a high level descriptions of the hardware device and software environment that embedded in the hardware device and a run time environment.

[0004] 2. Description of the Related Art

[0005] Typically any software running on a hardware/platform exercises the features of the hardware by way of device drivers. A device driver generally refers to a software code (group of software instructions), which enables a computing device (e.g., a computer system) to interface with a hardware device (e.g., a printer, a modem, a network controller card, etc.). The device driver provides appropriate interfaces enabling various software modules (e.g., user applications, operating system components, etc.) executing in the computing device (or hardware components in the computing device) to communicate with and/or to control the hardware device.

[0006] Device driver code is different for different computing devices generally due to differences in hardware and software characteristics among computing devices. For example, different operating systems (or its absence) may require different software codes for operation as a device driver in the corresponding computing devices. Similarly, having different hardware (devices, registers, etc.) characteristics may also require different software codes.

[0007] Device driver for a device is usually provided by one of the following means (i) sometimes written as part of applications, (ii) supplied as a standard component of an Operating System, (iii) written as a software component by a developer when he/she has a reference hardware platform and the run time environment. Typically, device driver writers use the description of the device features that are usually provided in English. This leads to ambiguity which results in quite a few to and fro between the hardware and software developers. There are a large number of combinations of different computing devices and operating environments (hardware and software characteristics). Since the information needed to write a device driver for a specific hardware device and/or operating system typically has to be obtained manually, it is cumbersome to write device drivers for these various combinations.

SUMMARY

[0008] In view of the foregoing, an embodiment herein provides a method of generating and validating a device driver for a hardware device. The method includes (i) dynamically querying the hardware device for a device programming specification, (ii) dynamically querying a run time environment for a run time specification, (iii) obtaining the device programming specification that is specific to the hardware device, (iv) obtaining the run time specification that is specific to the hardware device and the run time environment, (v) dynamically synthesizing a device driver by a device driver generation tool to obtain a synthesized device driver, (vi) automatically testing by the device driver generation tool the synthesized device driver by the device driver generation tool based on a device class of the hardware device, and (vii) automatically evaluating a performance of the synthesized driver with respect to standard performance parameters for the device class of the hardware device for validating the synthesized device driver. The device driver is specific to the hardware device and is generated based on the device programming specification and the run time specification.

[0009] The method may further include regenerating the synthesized device driver until no further errors are detected. The method may further include evaluating a quality of the synthesized device driver based on at least one of (a) a size of instructions associated with the device programming specification and the run time specification, and (b) a performance of the instructions. The method may further include generating a quality report of the synthesized device driver that is specific to the hardware device. The device programming specification may be stored in the hardware device and the run time specification may be stored in the run time environment of the computing device.

[0010] The method may further include obtaining a device obtaining a storage location of (a) the device programming specification based on the device ID and the vendor ID that is specific to the hardware device, and (b) the run time specification based on the hardware device and the run time environment. The method may further include obtaining (a) the device programming specification, and (b) the run time specification from an external storage device that is communicating with the computing device.

[0011] The method may further include providing at least one uniform resource locator for downloading the device programming specification. The device programming specification and the run time specification may be stored in at least one of (i) the computing device, (ii) the external storage device that is connected to the computing device, and (iii) a remote server that is in communication with the computing device.

[0012] In another aspect, a system for generating and validating a device driver for a hardware device is provided. The system include a computing device that include (a) at least one of (i) an operating system and (ii) a run time environment, (b) a device driver generation tool that generates the device driver for the hardware device, (c) a memory unit that stores (a) a database, and (b) a set of instructions, and (d) a processor that executes the set of instructions include (i) dynamically querying the hardware device for a device programming specification, (i) dynamically querying the run time environment for a run time specification, (iii) obtaining the device programming specification that is specific to the hardware device, (iv) obtaining the run time specification that is specific to the hardware device and the run time environment, (v) dynamically synthesizing a device driver by the device driver generation tool to obtain a synthesized device driver, (vi) automatically testing, by the device driver generation tool, the synthesized device driver based on a device class of the hardware device, and (vii) automatically evaluating, by the device driver generation tool, a performance of the synthesized

driver with respect to standard performance parameters for the device class of the hardware device for validating the synthesized device driver.

[0013] The device driver is specific to the hardware device and is generated based on the device programming specification and the run time specification. The set of instructions may further include regenerating the synthesized device driver until no further errors are detected. The set of instructions may further include evaluating a quality of the synthesized device driver based on at least one of (a) a size of instructions associated with the device programming specification and the run time specification, and (b) a performance of the instructions. The set of instructions may further include generating a quality report of the synthesized device driver that is specific to the hardware device. The device programming specification may be stored in the hardware device and the run time specification may be stored in the run time environment of the computing device. The set of instructions may further include obtaining a storage location of (a) the device programming specification based on a device ID and a vendor ID that is specific to the hardware device which is obtained from a configuration file, and (b) the run time specification based on the hardware device and the run time environment.

[0014] The set of instructions may further include obtaining (a) the device programming specification, and (b) the run time specification from an external storage device that is communicating with the computing device. The set of instructions may further include providing at least one uniform resource locator for downloading the device programming specification. The device programming specification and the run time specification may be stored in at least one of (i) the computing device, (ii) the external storage device that is connected to the computing device, and (iii) a remote server that is in communication with the computing device.

[0015] In yet another aspect, a method of generating and validating a device driver for a hardware device is provided. The method include (i) activating a boot code for a computing device, (ii) obtaining (a) information associated with at least one hardware device that is connected to the computing device, and (b) information associated with a hardware device for which a device driver is not present in the run time environment, (iii) obtaining a device ID, and a vendor ID from a configuration file, (iv) obtaining a storage location of (a) a device programming specification, and (b) a run time specification, (v) dynamically querying (i) the hardware device for the device programming specification, and (ii) the run time environment for the run time specification, (vi) obtaining the device programming specification that is specific to the hardware device, (vii) obtaining the run time specification that is specific to the hardware device, (viii) dynamically synthesizing a device driver to obtain a synthesized device driver, (ix) testing the synthesized device driver based on a device class of the hardware device, and (x) evaluating a performance of the synthesized driver with respect to standard performance parameters for the device class of the hardware device for validating the synthesized device driver. The computing device includes at least one of (i) an operating system, and (ii) a run time environment. The device driver is specific to the hardware device and is generated based on the device programming specification and the run time specification.

[0016] In further aspect, an embodiment herein provides a method of generating and validating a device driver for a hardware device. The method includes (i) dynamically querying the hardware device for a device programming specification, (ii) dynamically querying a run time environment for a run time specification, (iii) obtaining the device programming specification that is specific to the hardware device, (iv) obtaining the run time specification that is specific to the hardware device and the run time environment, and (v) dynamically synthesizing a device driver by a device driver generation tool to obtain a synthesized device driver.

[0017] These and other aspects of the embodiments herein will be better appreciated and understood when considered in conjunction with the following description and the accompanying drawings. It should be understood, however, that the following descriptions, while indicating preferred embodiments and numerous specific details thereof, are given by way of illustration and not of limitation. Many changes and modifications may be made within the scope of the embodiments herein without departing from the spirit thereof, and the embodiments herein include all such modifications.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] The embodiments herein will be better understood from the following detailed description with reference to the drawings, in which:

[0019] FIG. **1**A through FIG. **1**C illustrates a block diagram for generating a device driver for an existing hardware device according to an embodiment herein;

[0020] FIG. **2**A through FIG. **2**C illustrates a block diagram for generating a device driver for the existing hardware device when the device programming specification is in the hardware device and a run time specification is in a run time environment of the computing device of FIG. **1**A-**1**C according to an embodiment herein;

[0021] FIG. **3**A through FIG. **3**C illustrates a block diagram for generating a device driver for the primary network device of FIG. **1**A-**1**C when the device programming specification is not available for the network device according to an embodiment herein; and

[0022] FIG. **4**A through FIG. **4**C is a flow chart illustrating a method of generating a device driver for the hardware device and testing the device driver for functionality on the computing device using the device driver generation tool of FIG. **1**A-**1**C according to an embodiment herein;

[0023] FIG. **5** is a flow chart illustrating a method of generating a device driver for the hardware device and testing the device driver for functionality on the computing device using the device driver generation tool of FIG. **1**A-**1**C according to an embodiment herein;

[0024] FIG. **6** illustrates a schematic diagram of the hardware device of FIG. **1**A-**1**C to perform any one or more of the methodologies herein, according to an embodiment herein; and

[0025] FIG. **7** illustrates a schematic diagram of a computer architecture used in accordance with the embodiments herein.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0026] The embodiments herein and the various features and advantageous details thereof are explained more fully with reference to the non-limiting embodiments that are illustrated in the accompanying drawings and detailed in the following description. Descriptions of well-known components and processing techniques are omitted so as to not unneces-

sarily obscure the embodiments herein. The examples used herein are intended merely to facilitate an understanding of ways in which the embodiments herein may be practiced and to further enable those of skill in the art to practice the embodiments herein. Accordingly, the examples should not be construed as limiting the scope of the embodiments herein.

[0027] As mentioned, there remains a need for a device driver generation tool to generate a device driver and test the device driver for functionality on the go using a high level description of a hardware device and software environment embedded in the hardware device. The embodiments herein achieve this by providing a device driver generation tool generates, synthesizes and deploys the device driver. During the synthesis-deployment phase, the device driver is validated by attempting for auto-correction to identify and fix the errors. The ability of the device driver generation tool to attempt for auto-correction eliminates, to some basic level the need of user intervention to correct any errors. The device driver generation tool further generates report indicating a quality of the device driver. The user gets user manual regarding the APIs provided by the device driver thus helping out in application development. This tool eases the process both in terms of effort and time for porting operating systems on a platform since now the porting has to be done only for the processor and all the drivers will be automatically generated. Referring now to the drawings, and more particularly to FIGS. **1**A through FIG. **7**, where similar reference characters denote corresponding features consistently throughout the figures, there are shown preferred embodiments.

[0028] FIG. **1**A through FIG. **1**C illustrates a block diagram for generating a device driver for an existing hardware device (which is not the primary network device of the computing device) according to an embodiment herein. The block diagram includes a computing device **102** having a device driver generation tool **104**, the hardware device **106** having a configuration file **108**, and a network device **110**. The hardware device **106** is not a primary network device, in one example embodiment. The computing device **102** has an operating system or a run time environment (RTE). The DPS is not embedded in the hardware device **106** and the RTS is not present in the operating system (e.g., the run time environment (RTE)), in one example embodiment. The user provides a configuration file that includes a device ID and a vendor ID. The device driver generation tool **104** reads the configuration file (as shown in FIG. **1**A) and downloads an appropriate device programming specification (DPS) and run time specification (RTS) from the external storage as shown in FIG. **1**B. The external storage may be on a dedicated server, or stored on a cloud, or on an external hard disk, in one example. In one embodiment, the computing device **102** may be a smart phone, a tablet PC, a laptop, a desktop, and an ultra-book. The device driver generation tool **104** then generates the device driver for the existing hardware device, validates, deploys the device driver and generates reports as shown in FIG. **1**C.

[0029] FIG. **2**A through FIG. **2**C illustrates a block diagram for generating a device driver for the existing hardware device when the DPS is in the hardware device **106** and the RTS is in the RTE of the computing device **102** of FIG. **1**A-**1**C according to an embodiment herein. The device driver generation tool **104** receives a device programming specification (embedded in the hardware device **106**) by querying the hardware device **106** in one embodiment. For example, the device programming specification (DPS) is embedded in the hardware device **106** when the hardware device **106** provides an internal memory and one or more registers with one or more byte size each at predefined locations.

[0030] In one embodiment, the hardware device **106** provides approximately 50 KB internal memory, three registers of 4 bytes size each at offset 0, 4 and 8. The register at location 0 may have 0x766C616273 as a default value. The register at the offset 4 may have a size of the DPS file that is stored in the hardware device memory and then the register at offset 8 provide access to the internal memory containing a compressed version of DPS. In an example embodiment, when the device driver generation tool **104** may first read register at offset 0 of the hardware device. If the value read is 0x766C616273, the device driver generation tool **104** may read the value stored in the register at offset 4 to determine number of byte to be read for obtaining a complete DPS stored in the internal memory of the hardware device. The device driver generation tool **104** may proceed to read the number of bytes read from register at offset 8. The device driver generation tool **104** may proceed to decrypt and uncompressed DPS may be generated.

[0031] Similarly, the device driver generation tool **104** receives the run time specification (embedded in the run time environment that is executed on the computing device **102**) by querying the run time environment installed on the computing device **102**. In one embodiment, the run time specification may be embedded (e.g., stored or bundled) within the runtime environment (e.g., an operating system) during the production process. For example, The operating system may have a specific directory at a root level of a file system (e.g., In case of A**1** operating system is C:\ABC and in case of A**2** operating system is C:\XYZ). The device driver generation tool **104** may consider a device id (either by querying the hardware device **106** or by obtaining information from a configuration file). The device driver generation tool **104** searches the ABC folder to check if an RTS corresponding to the device id is present in the directory. If the RTS is present the device driver generation tool **104** may proceed to uncompress it. If the RTS is not present the device driver generation tool **104** may proceed to obtain from the internet (either from a server or from the cloud) and uncompress it.

[0032] This scenario enables an end user (e.g., a customer or a person of ordinary skill in the art) to generate a device driver for the hardware device **106** using the device driver generation tool **104** (which may be executed in the computing device **102**). This further eliminates the need of downloading the device driver from the internet. For example,

[0033] The device driver generation tool **104** queries the hardware device **106** for the DPS and extracts the DPS from the hardware device as shown in FIG. **2**A. Similarly, the device driver generation tool **104** queries the run time environment (RTE) and extracts the run time specification (RTS) from the run time environment (RTE) as shown in FIG. **2**B. The device driver generation tool **104** then generates the device driver for the existing hardware device, validates, deploys the device driver and generates reports as shown in FIG. **2**C.

[0034] FIG. **3**A through FIG. **3**C illustrates a block diagram for generating a device driver for the primary network device **110** of FIG. **1**A-**1**C when the DPS is not available for the network device **110** according to an embodiment herein. In one embodiment, the device driver generation tool **104** queries the network device **110** to obtain the device ID and vendor ID as shown in FIG. **3**A. For example, the network device **110** is a primary network device of the computing

device **102**. Hence, the device driver generation tool **104** cannot access and use the network device **110** to obtain the DPS. However, one or more URLs are displayed to the user from which the DPS can be downloaded. The URL of the DPS stored on a remote server is displayed to the user as shown in FIG. **3**B. The device driver generation tool **104** waits until the user provides the target location for the DPS. Similarly, the device driver generation tool queries the RTE for the RTS as shown in FIG. **3**A. Upon obtaining the DPS and the RTS, the device driver generation tool **104** then generates the device driver for the network device **110**, validates, deploys the device driver and generates reports.

[0035] FIG. **4**A through FIG. **4**C is a flow chart illustrating a method of generating a device driver for a hardware device and testing the device driver for functionality on the computing device **102** using the device driver generation tool **104** of FIG. **1**A-**1**C according to an embodiment herein. In step **402**, boot code for a computing device is activated. In step **404**, check whether the hardware device is a primary network device. If the hardware device is the primary network device, then it is checked whether a device program specification (DPS) and a run time specification (RTS) are available locally on the computing device **102**, in step **406**. If the DPS and the RTS are not available locally on the computing device **102**, a user associated with the computing device **102** is informed about the location of the DPS (and if required RTS), in step **408**. In one embodiment, the device driver generation tool prompts the user the location of the DPS and the RTS and how to obtain the externally stored DPS and/or RTS.

[0036] In step **410**, the device driver is generated and synthesized for the hardware device based on the DPS and the RTS. In one embodiment, the device driver generation tool **104** dynamically synthesis the device driver by detecting and querying of the hardware device after RTE/Operating system boot up. If the DPS and RTS are available locally, then the device driver is generated and synthesized for the hardware device based on the DPS and the RTS without having to perform the step **408**.

[0037] If the hardware device is not the primary network device, then the DPS are queried in the hardware device **106** and the RTS are queried in the run time environment (RTE) **104**, in step **412**. In one embodiment, then the DPS and the RTS are dynamically queried for in the hardware device and in the run time environment (RTE) respectively. In step **414**, it is checked whether the DPS and the RTS are stored (i) internally in the hardware device or (ii) externally on a storage device or on a remote server. If the DPS and the RTS are stored internally in the hardware device, the DPS and the RTS are extracted in step **416**, and the step **410** is performed. If the DPS and/or the RTS are stored externally on the storage device or on the remote server, then the DPS and/or the RTS are accessed from the storage device or from the remote server in step **418**, and the step **410** is performed.

[0038] In step **420**, the device driver is validated. In one embodiment, validation of the synthesized device driver is performed when the synthesized device driver is executed on the hardware device. In one embodiment, the device driver generation tool **104** automatically validates the functionality of the synthesized device driver by executing it on the hardware device **106** to detect possible defects, evaluates the device driver qualitatively in terms of size of code, performance of the code etc., and performs a conformance test to ensure that the device driver adheres to the conformance criteria as required by the RTE/Operating system like that of WHQL.

[0039] In step **422**, it is checked whether there are any errors in the device driver. If there are no errors in the device driver, then a quality check is performed and a report is generated in step **424**. The report helps the application writer in using the device driver by providing information about the APIs provided by the device driver. In step **426**, the device driver is deployed. If there are errors in the device driver, the device driver generation tool attempts for auto-correction, in step **428**. In step **430**, the device driver generation tool revalidates the device driver after performing auto-correction. In one embodiment, in case of error detection during validation, the device driver generation tool **104** attempts for automatic error correction using standard observation debug points that have been already inserted in the hardware device.

[0040] In step **432**, it is checked whether there are any more errors in the device driver. If there are no errors in the device driver then the step **426** is performed. Else, if there are errors, the device driver may be manually corrected in step **434**, and the step **420** may be performed. In one embodiment, if the device driver generation tool **104** detects any problems during the validation phase, it will attempt to correct the problems and report the pass or failure of the device driver generation process. Based on this report, the user can then attempt to do any manual corrections and re-run the device driver generation tool **104** based on a request received and/or displayed on a display of the computing device **102** by the device driver generation tool **104**.

[0041] FIG. **5** is a flow chart illustrating a method of generating a device driver for the hardware device and testing the device driver for functionality on the computing device using the device driver generation tool of FIG. **1**A-**1**C according to an embodiment herein. In step **502**, a hardware device is dynamically queried for a device programming specification. In one embodiment, the device driver generation tool **104** queries the hardware device for the device programming specification. In step **504**, a run time environment is dynamically queried for a run time specification. In one embodiment, the device driver generation tool **104** queries the run time environment for the run time specification. In step **506**, the device programming specification that is specific to the hardware device is obtained. In step **508**, the run time specification that is specific to the hardware device is obtained.

[0042] In step **510**, a device driver is dynamically synthesized to obtain a synthesized device driver based on the device programming specification and the run time specification. In step **512**, the synthesized device driver is tested based on a device class of the hardware device. For example, the synthesized device driver is deployed tested based on the device class (e.g., enumeration and file copy for USB memory storage device or ping for network device).

[0043] In step **514**, a performance of the synthesized device driver is evaluated with respect to standard performance parameters for the device class of the hardware device for validating the synthesized device driver. For example, performance of the synthesized driver is evaluated using standard test suites and a report is generated. The report may include standard expected performance for each device class and version (USB 2.0 devices performance will be less that of USB 3.0 devices or in case of Ethernet cards a 100 Mbps device will performance will be less than that of a 1 Gbps device which in turn will perform worse than a 10 Gbps

device. Hence the database may include expected performance for each and every variation. In one embodiment, standard size of device driver for different device classes may be stored and the size of the synthesized device driver may be compared against the standard expected device driver size stored in a database using a device class and a device id as key to search in the database.

[0044] In one embodiment, the synthesized device driver is regenerated until no further errors are detected. For example, when the test fails for the synthesized device driver, the synthesized device driver is regenerated with access to standard observation debug points (which are not usual device registers). The standard observation debug points may allow the driver access and display a actual signal values/status at various pins and buses in the computing device (what is the signal value at the interrupt pin(s) of the device?).

[0045] In one embodiment, a quality of the synthesized device driver is evaluated based on one or more (i) a size of instructions associated with the device programming specification and the run time specification, and (ii) performance of the instructions. In one embodiment, a quality report of the synthesized device driver that is specific to the hardware device is generated.

[0046] For example, the device programming specification is obtained from the hardware device and the run time specification is obtained from the run time environment of the computing device when the device programming specification is embed within the hardware device. Similarly, the run time specification is embed within the run time environment of the computing device.

[0047] In another example embodiment, a device ID and a vendor ID that is specific to the hardware device is obtained. A storage location of (a) the device programming specification, and (b) the run time specification is obtained based on the device ID and the vendor ID that is specific to the hardware device. Then automatically the device programming specification and (b) the run time specification are obtained from an external storage device that is communicating with the computing device.

[0048] In one embodiment, at least one uniform resource locator is provided for downloading the device programming specification. In one embodiment, the device programming specification and the run time specification are stored in at least one of (i) the computing device, (ii) an external storage device that is connected to the computing device, and (iii) a remote server that is in communication with the computing device.

[0049] FIG. **6** illustrates a schematic diagram of the hardware device **106** of FIG. **1**A-**1**C having an a memory **602** having a set of computer instructions, a bus **604**, a display **606**, a speaker **608**, and a processor **610** capable of processing a set of instructions to perform any one or more of the methodologies herein, according to an embodiment herein. The processor **610** may also enable digital content to be consumed in the form of video for output via one or more displays **606** or audio for output via speaker and/or earphones **608**. The processor **610** may also carry out the methods described herein and in accordance with the embodiments herein.

[0050] Digital content may also be stored in the memory **602** for future processing or consumption. The memory **6602** may also store program specific information and/or service information (PSI/SI), including information about digital content (e.g., the detected information bits) available in the future or stored from the past. A user of the hardware device **106** may view this stored information on display **606** and select an item of for viewing, listening, or other uses via input, which may take the form of keypad, scroll, or other input device(s) or combinations thereof. When digital content is selected, the processor **610** may pass information. The content and PSI/SI may be passed among functions within the hardware device **106** using the bus **604**.

[0051] The techniques provided by the embodiments herein may be implemented on an integrated circuit chip (not shown). The chip design is created in a graphical computer programming language, and stored in a computer storage medium (such as a disk, tape, physical hard drive, or virtual hard drive such as in a storage access network). If the designer does not fabricate chips or the photolithographic masks used to fabricate chips, the designer transmits the resulting design by physical means (e.g., by providing a copy of the storage medium storing the design) or electronically (e.g., through the Internet) to such entities, directly or indirectly.

[0052] The stored design is then converted into the appropriate format (e.g., GDSII) for the fabrication of photolithographic masks, which typically include multiple copies of the chip design in question that are to be formed on a wafer. The photolithographic masks are utilized to define areas of the wafer (and/or the layers thereon) to be etched or otherwise processed.

[0053] The resulting integrated circuit chips can be distributed by the fabricator in raw wafer form (that is, as a single wafer that has multiple unpackaged chips), as a bare die, or in a packaged form. In the latter case the chip is mounted in a single chip package (such as a plastic carrier, with leads that are affixed to a motherboard or other higher level carrier) or in a multichip package (such as a ceramic carrier that has either or both surface interconnections or buried interconnections).

[0054] In any case the chip is then integrated with other chips, discrete circuit elements, and/or other signal processing devices as part of either (a) an intermediate content, such as a motherboard, or (b) an end content. The end content can be any content that includes integrated circuit chips, ranging from toys and other low-end applications to advanced computer contents having a display, a keyboard or other input device, and a central processor.

[0055] The embodiments herein can take the form of an entirely hardware embodiment, an entirely software embodiment or an embodiment including both hardware and software elements. The embodiments that are implemented in software include but are not limited to, firmware, resident software, microcode, etc.

[0056] Furthermore, the embodiments herein can take the form of a computer program content accessible from a computer-usable or computer-readable medium providing program code for use by or in connection with a computer or any instruction execution system. For the purposes of this description, a computer-usable or computer readable medium can be any apparatus that can comprise, store, communicate, propagate, or transport the program for use by or in connection with the instruction execution system, apparatus, or device.

[0057] The medium can be an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system (or apparatus or device) or a propagation medium. Examples of a computer-readable medium include a semiconductor or solid state memory, magnetic tape, a removable computer diskette, a random access memory (RAM), a read-only memory (ROM), a rigid magnetic disk and an optical disk. Current

examples of optical disks include compact disk-read only memory (CD-ROM), compact disk-read/write (CD-R/W) and DVD.

[0058] A data processing system suitable for storing and/or executing program code will include at least one processor coupled directly or indirectly to memory elements through a system bus. The memory elements can include local memory employed during actual execution of the program code, bulk storage, and cache memories which provide temporary storage of at least some program code in order to reduce the number of times code must be retrieved from bulk storage during execution.

[0059] Input/output (I/O) devices (including but not limited to keyboards, displays, pointing devices, etc.) can be coupled to the system either directly or through intervening I/O controllers. Network adapters may also be coupled to the system to enable the data processing system to become coupled to other data processing systems or remote printers or storage devices through intervening private or public networks. Modems, cable modem and Ethernet cards are just a few of the currently available types of network adapters.

[0060] A representative hardware environment for practicing the embodiments herein is depicted in FIG. **7**. This schematic drawing illustrates a hardware configuration of an information handling/computer system in accordance with the embodiments herein. The system comprises at least one processor or central processing unit (CPU) **10**. The CPUs **10** are interconnected via system bus **12** to various devices such as a random access memory (RAM) **14**, read-only memory (ROM) **16**, and an input/output (I/O) adapter **18**. The I/O adapter **18** can connect to peripheral devices, such as disk units **11** and tape drives **13**, or other program storage devices that are readable by the system. The system can read the inventive instructions on the program storage devices and follow these instructions to execute the methodology of the embodiments herein.

[0061] The system further includes a user interface adapter **19** that connects a keyboard **15**, mouse **17**, speaker **24**, microphone **22**, and/or other user interface devices such as a touch screen device (not shown) to the bus **12** to gather user input. Additionally, a communication adapter **20** connects the bus **12** to a data processing network **25**, and a display adapter **21** connects the bus **12** to a display device **23** which may be embodied as an output device such as a monitor, printer, or transmitter, for example.

[0062] The device driver generation tool **104** eliminates the need to worry about getting driver written or synthesized externally by procuring a tool. When the RTE boots up automatically the driver gets synthesized and deployed. During the synthesis-deployment phase, the device driver generation tool **104** attempts auto-correction to fix any errors that are identified as part of device driver validation. The device programming specification (DPS) is embedded in the hardware device and the run time specification (RTS) is embedded in the run time environment. Hence, information needed for generating the device driver that is present in the operating system and in the hardware device. This scenario enables an end user (e.g., a customer or a person of ordinary skill in the art) to generate a device driver for the hardware device **106** using the device driver generation tool **104** (which may be executed in the computing device **102**). This further eliminates the need of downloading the device driver from the internet. The ability of the device driver generation tool to attempt for auto-correction eliminates the need of user intervention to correct any errors or may provide an indication to manually correct the errors. The device driver generation tool further generates report indicating a quality of the device driver. The user gets user manual regarding the APIs provided by the device driver thus helping out in application development. This tool eases the process both in terms of effort and time for porting operating systems on a platform since now the porting has to be done only for the processor and all the drivers will be automatically generated.

[0063] The foregoing description of the specific embodiments will so fully reveal the general nature of the embodiments herein that others can, by applying current knowledge, readily modify and/or adapt for various applications such specific embodiments without departing from the generic concept, and, therefore, such adaptations and modifications should and are intended to be comprehended within the meaning and range of equivalents of the disclosed embodiments. It is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation. Therefore, while the embodiments herein have been described in terms of preferred embodiments, those skilled in the art will recognize that the embodiments herein can be practiced with modification within the spirit and scope of the appended claims.

What is claimed is:

1. A method of generating and validating a device driver for a hardware device, said method comprising:

(i) dynamically querying said hardware device for a device programming specification;

(ii) dynamically querying a run time environment for a run time specification;

(iii) obtaining said device programming specification that is specific to said hardware device;

(iv) obtaining said run time specification that is specific to said hardware device and said run time environment;

(v) dynamically synthesizing a device driver, by a device driver generation tool to obtain a synthesized device driver, wherein said device driver is specific to said hardware device and is generated based on said device programming specification and said run time specification;

(vi) automatically testing, by said device driver generation tool, said synthesized device driver based on a device class of said hardware device; and

(vii) automatically evaluating, by said device driver generation tool, a performance of said synthesized driver with respect to standard performance parameters for said device class of said hardware device for validating said synthesized device driver.

2. The method of claim **1**, further comprising regenerating said synthesized device driver until no further errors are detected.

3. The method of claim **1**, further comprising evaluating a quality of said synthesized device driver based on at least one of (a) a size of instructions associated with said device programming specification and said run time specification, and (b) a performance of said instructions.

4. The method of claim **3**, further comprising generating a quality report of said synthesized device driver that is specific to said hardware device.

5. The method of claim **1**, wherein said device programming specification is stored in said hardware device, and wherein said run time specification is stored in said run time environment of said computing device.

6. The method of claim **1**, further comprising obtaining a device ID and a vendor ID that is specific to said hardware device.

7. The method of claim **6**, further comprising obtaining a storage location of (a) said device programming specification based on said device ID and said vendor ID that is specific to said hardware device, and (b) said run time specification based on said hardware device and said run time environment.

8. The method of claim **7**, further comprising obtaining (a) said device programming specification, and (b) said run time specification from an external storage device that is communicating with said computing device.

9. The method of claim **1**, further comprising providing at least one uniform resource locator for downloading said device programming specification.

10. The method of claim **1**, wherein said device programming specification and said run time specification are stored in at least one of (i) said computing device, (ii) said external storage device that is connected to said computing device, and (iii) a remote server that is in communication with said computing device.

11. A system for generating and validating a device driver for a hardware device, said system comprising:

(i) a computing device that comprises

(a) at least one of (i) an operating system and (ii) a run time environment;

(b) a device driver generation tool that generates said device driver for said hardware device;

(c) a memory unit that stores (a) a database, and (b) a set of instructions; and

(d) a processor that executes said set of instructions comprising:

(i) dynamically querying said hardware device for a device programming specification;

(ii) dynamically querying a run time environment for a run time specification;

(iii) obtaining said device programming specification that is specific to said hardware device;

(iv) obtaining said run time specification that is specific to said hardware device and said run time environment;

(v) dynamically synthesizing a device driver by said device driver generation tool to obtain a synthesized device driver, wherein said device driver is specific to said hardware device and is generated based on said device programming specification and said run time specification;

(vi) automatically testing, by said device driver generation tool said synthesized device driver based on a device class of said hardware device; and

(vii) automatically evaluating, by said device driver generation tool, a performance of said synthesized driver with respect to standard performance parameters for said device class of said hardware device for validating said synthesized device driver.

12. The system of claim **11**, wherein said set of instructions further comprises regenerating said synthesized device driver until no further errors are detected.

13. The system of claim **11**, wherein said set of instructions further comprises evaluating a quality of said synthesized device driver based on at least one of (a) a size of instructions associated with said device programming specification and said run time specification, and (b) a performance of said instructions.

14. The system of claim **13**, wherein said set of instructions further comprises generating a quality report of said synthesized device driver that is specific to said hardware device.

15. The system of claim **11**, wherein said device programming specification is stored in said hardware device, and wherein said run time specification is stored in said run time environment of said computing device.

16. The system of claim **11**, wherein said set of instructions further comprises obtaining a storage location of (a) said device programming specification based on a device ID and a vendor ID that is specific to said hardware device that are obtained from a configuration file, and (b) said run time specification based on said hardware device and said run time environment.

17. The system of claim **16**, wherein said set of instructions further comprises obtaining (a) said device programming specification, and (b) said run time specification from an external storage device that is in communication with said computing device.

18. The system of claim **11**, wherein said set of instructions further comprises providing at least one uniform resource locator for downloading said device programming specification.

19. The system of claim **11**, wherein said device programming specification and said run time specification are stored in at least one of (i) said computing device, (ii) said external storage device that is connected to said computing device, and (iii) a remote server that is in communication with said computing device.

20. A method of generating and validating a device driver for a hardware device, said method comprising:

(i) activating a boot code for a computing device, wherein said computing device comprises at least one of (i) an operating system, and (ii) a run time environment;

(ii) obtaining (a) information associated with at least one hardware device that is connected to said computing device, and (b) information associated with a hardware device for which a device driver is not present in said run time environment;

(iii) obtaining a device ID, and a vendor ID from a configuration file;

(iv) obtaining a storage location of (a) a device programming specification, and (b) a run time specification;

(v) dynamically querying (i) said hardware device for said device programming specification, and (ii) said run time environment for said run time specification;

(vi) obtaining said device programming specification that is specific to said hardware device;

(vii) obtaining said run time specification that is specific to said hardware device and said run time environment;

(viii) dynamically synthesizing a device driver, by a device driver generation tool, to obtain a synthesized device driver, wherein said device driver is specific to said hardware device and is generated based on said device programming specification and said run time specification;

(ix) testing, by said device driver generation tool, said synthesized device driver based on a device class of said hardware device; and

(x) evaluating, by said device driver generation tool, a performance of said synthesized driver with respect to standard performance parameters for said device class of said hardware device for validating said synthesized device driver.

21. A method of generating and validating a device driver for a hardware device, said method comprising:

(i) dynamically querying said hardware device for a device programming specification;

(ii) dynamically querying a run time environment for a run time specification;

(iii) obtaining said device programming specification that is specific to said hardware device;

(iv) obtaining said run time specification that is specific to said hardware device and said run time environment; and

(v) dynamically synthesizing a device driver, by a device driver generation tool to obtain a synthesized device driver, wherein said device driver is specific to said hardware device and is generated based on said device programming specification and said run time specification.

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